DOCUMENT No. 37.

BOARD

OF THE

Department of Public Parks.

MAY 22, 1872.

Resolved, That the Report of the Board of Engineers on Concrete Pavements, presented at the last meeting, be printed as a document of this Board.

E. P. BARKER,
Clerk.

REPORT

UPON

CONCRETE PAVEMENTS,

PRINCIPALLY WITH REGARD TO COMPOSITIONS IN WHICH BITUMINOUS MATERIAL IS USED.

In accordance with the objects set forth in a communication by the Hon. H. G. Stebbins, President of the Department of Parks of the city of New York (suggesting the desirability of an examination by competent persons into the merits of the various concrete pavements, together with an expression of judgment as to their value for general or limited use, as would result from such examination, and a systematic discussion of the subject), and addressed to the Park Commissioners of the cities of Brooklyn, Philadelphia and Buffalo, and the Metropolitan Board of Works of the city of Washington, a Board of Engineers representing these several organizations convened at the offices of the Department of Parks, New York City, on Tuesday, March 12th, 1872, continued their session on the 13th inst., and subsequently adjourned to, and met in, the city of Philadelphia, on the 26th and 27th instant.

During this period the members of the Board examined all the pavements laid in these cities, and, notably, those in the parks and public squares. Of the large number and variety put down in this country, it may be stated that good samples of the most important of those which seemed to offer any

reasonable hope of success, were found on one or all of these parks and squares, and presented all the advantages for observation as to length of time laid, abrasion to which they had been exposed, and condition under such exposure, which the Board deemed of value for the purposes of their investigations. The pavements so examined were put down by the companies designated in the following list, viz.:

The Scrimshaw Patent Pavement Co.,
The Scharf Patent Pavement Co.,
The Grahamite Asphalt Pavement Co.,
The Evans Pavement Co.,
The Day Vulcanite Pavement Co.,
The Filbert Vulcanite Pavement Co.,

together with some others, whose operations, however, had been too limited to warrant special mention. These had been in use for various periods from the year 1867 to date. Samples of nearly all exhibited favorable conditions, as to wear, and presented smooth, well formed and compact surfaces, with fair indications of continued durability.

These examinations and the resulting discussions were facilitated by prompt and full responses to the following communication, addressed to a number of the companies engaged in the laying of composition pavements:

March 13th, 1872.

The Company.

Gentlemen,—A Board of Engineers, representing the Park Commissioners of the cities of New York, Brooklyn, Philadelphia, Buffalo and the Department of Public Works at Washington, have under discussion the question of the practicability of Concrete Pavement for pleasure drives and traffic roads, and are seeking information with the view to determine generally the requisites of a desirable pavement for such purposes. It is also their desire to investigate the subject of treating the concreting material with the view to determine, if possible, the best conditions under which it may be used.

To these ends I am requested to ask of you a written specifi-

cation of your pavement, seting forth, as fully as you may be inclined to do so, the materials used in their several proportions, the processes of manipulating, together with the form and mode of laying the same. In this connection we should like to have the statement show the bulks in depth which you offer for.

1st. Paths of public grounds and side-walks .
with price per square yard superficial.

2d. Pleasure drives or roads for light travel " "

3d. Traffic roads, including heavy travel " "

You may, if you please, cite samples of pavement laid by you which offer favorable experience, with the time of laying, the class of wear to which it has been subjected, &c., and any remarks concerning the question of surface color you may be pleased to offer. This information is for the use of this Board only.

Respectfully,
JOHN Y. CULYER,
Secretary of the Board.

Communications to be addressed to
JOHN Y. CULYER,
Chief Engineer,
Brooklyn Parks Commission.

As is known, the principal and essential ingredients which are made use of in the composition of bituminous pavements, are broken stone, gravel, sand (or ashes, cinders, slag, vitrified clay and glass refuse, intended in part to replace these) with bitumen of asphalt or coal tar, as the concreting substance. In addition to these, there are other materials used which may be found of more or less service

It may not be out of place to mention that nearly one hundred patents have been issued by our government for these new and useful inventions so-called; and when it is further observed that for the purpose of fulfilling the very flimsy requirements of

the law, the patentees have been permitted to include in their specifications (under the pretense of using them as desirable ingredients) such rubbish as saw-dust, shavings, charcoal dust, peat, &c, it may be reasonably questioned how far the operation of this branch of our government serves to encourage and foster honest talent and industry, and specially the development of really useful and substantial improvement in desirable pavement compositions. Less than fifteen of these patented compositions present to-day any claims to the attention of practical men, and perhaps not one-half of these have more than partially succeeded, and some have totally failed for want of correct knowledge and experience (in combining and manipulating materials) on the part of the patentee.

A pavement composed of broken stone, gravel, sand, or their equivalents, if they can be found, united with asphalt and coal-tar bitumen, properly prepared, without doubt, will make a roadway which shall prove both cheap and durable; but no process now in use, so far as known to the members of the Board, by which any of the pavements are at present manufactured, offer such conditions of uniformity in the manipulation of the work as to warrant assurances of substantial success.

As a result of their discussions, the members of the Board endeavor to present in this report some general conclusions as to the materials used, the manner of working them, and such other conditions as seem necessary in their judgment to render this class of pavement of practical value.

The bituminous limestones of France, and especially the richest of these, that of the Val de Travers, in the canton of Neufchâtel, of which the asphaltic pavement laid in Paris, London and elsewhere is composed, is believed to be the best material for this class of work. This interesting mineral deposit occurs in the Jurassic limestone formation, and is the equivalent of the English oolite.

The percentage of bitumen in natural combination with the limestone is large, containing, according to a statement in the specifications of Claridge's patent of November, 1837, carb. of lime and bitumen in about the proportion of 90 parts of carb. of lime to 10 parts of bitumen. No material which corresponds to this has as yet been found in this country.

What effect the climate and changes of temperature here will have upon this material is not yet known; possibly the range and alternations of heat and cold will subject it to severe tests, with results differing from European experience.

Samples are to be laid in this country during the current year.

This bitumen is so intimately and evenly distributed throughout the limestone, that when prepared for surface application it readily re-unites and forms a complete and homogenous mass with very little labor.

It has not been possible, so far, to produce by mechanical combinations, a composition which meets the requirements of a good pavement so well. Asphalt and coal-tar bitumen, however, is substituted, and is found to answer very well. Much, doubtless, is yet to be learned as to the best mode of their mechanical and chemical treatment. Their sale and use for the manufacture of composition pavement has very largely increased during the last few years.

No doubt exists as to a sufficiency of supply to meet the constantly increasing demands for them.

By inquiries and investigations, in which the Board were assisted by Professor Chandler, Ph. D., Professor of Chemistry of the School of Mines, Columbia College, N. Y., it was found that a serious impediment to their successful use lay in the manner in which the asphalt was prepared for shipment to this country from the Island of Trinidad, and other places where its deposits are found.

The operation of refining is very imperfectly done, so that variable and sometimes large percentages of refuse and deleterious matter, as bituminous scoriæ, vitrified sand, cinders, &c., is contained in the material, as supplied for use. Dr. Ure, in several analyses, states that he found from 20 to 30 per cent. of this refuse matter. This variable nature in the quality of the asphalt not only seriously impairs its value, but likewise renders somewhat uncertain the results of its use, where fixed rules as to given quantities have been established.

It is also believed that a serious objection exists in the manner in which the material is treated for the purpose of separating the foreign substances that may be contained in the asphalt when quarried, and in distilling volatile matter.

Investigation seems to indicate that the heat is applied in an irregular and unsystematic manner, and with such carelessness as to frequently destroy much of the valuable part of the asphalt. In this condition, after being placed in barrels, and shipped to market, without any mark or brand to indicate its impaired value or uselessness, it finds its way into the hands of the contractor, who, with ever so sound a formula in theory, will fail of a satisfactory practical result, when this burned or calcined or otherwise defectively treated material is used, in spite of the most conscientious efforts on his part to make a good piece of work. The same general objections are equally applicable to the use of coal-tar, as prepared and used at present.

The preparation of asphaltic and coal-tar bitumen, to make it most valuable for the use herein discussed, must involve improved machinery, a more extended scientific supervision and systematic labor. Such processes will necessarily enhance the first cost of the material, but its subsequent value, resulting from its known uniformity of character and reliability, will increase in proportion as the standard established as to quality is improved, and the strictness and honesty with which manufacturers adhere to it.

The manufacture and laying of pavements, that has been done in nearly all cases, has been in the form of a series of imperfect experiments, in which the preparation and combination of the materials have been so frequently modified as to present but little value, so far as repeated application of a well developed principle is concerned.

Any process which will not, with reasonable certainty, secure the uniform application of heat to, and proper supervision over, the distillation necessary to bring the material to its most desirable condition, will prove objectionable for these two reasons, viz.:

1st. It will either result in the destruction of valuable properties of the material, or

2d. Will impair its usefulness to an almost equal degree, by the imperfect evolution or distillation of volatile or other useless matter.

With regard to coal-tar, the same difficulties arise as to its treatment for use, as a concreting material, and it is only the result of recent experience that its careful reduction or distillation was found to be desirable or necessary at all.

When drawn from the receivers, it contains a large percentage of useless matter—water and the light or volatile oils. The value of its solid portions varies under the circumstances of the kind of coal used and the variations in the process of producing the gas.

The use of crude coal-tar, as ordinarily produced by the manufacture of gas, is unequivocally condemned.

The use of pine or wood-tar in any form is also condemned.

The use of steam for the heating purposes will be found to be most effective, and its adoption, both for the preparation of the crude asphalt and coal-tar for market, as far as it may be possible to do so, as well as by the manufacturer of pavements, for the several processes of manipulating his materials, will, in the opinion of the Board, go far towards securing most desirable results. All the operations and processes under which any of these classes of pavements are to be laid, should be clearly stated and understood by those for whom the work is to be done, before work is commenced. The work should be subjected to rigid supervision by an engineer, or other competent person; whatever temperature may be required by the process in hand, such temperature should be known, and carefully conformed to.

Much information will be derived in the future, regarding the best mode of composing and laying these pavements; up to this year, no business enterprise, involving such extensive labor and material interests, seem to have lacked, to such a degree, the results and advantages of intelligent and systematic experiments.

As the question now stands, careful observations, accompanied by a thorough record of all the circumstances attending the doing of any work hereafter, will be of great value. These observations and record should begin with the preparation of the surfaces upon which the pavement is to be laid, noting the character of the soil, the conditions and peculiarities which may be met with, such as erratic deposits of clay, quicksand,

springs, &c., &c., requiring special treatment, also the material used in the superstructure, the specifications under which they are laid, length and time of laying, and such other details as will be naturally suggested as valuable to a thorough knowledge of the conditions under which the work was done.

A series of observations under such circumstances, carried on during two consecutive seasons, in connection with work laid by any or all of the reputable companies engaged in this work, will prove of exceptional value alike to the manufacturer as to those seeking information as to their practicability and usefulness.

The requirements and characteristics of a good roadway are very much the same as regards their construction, whether it be of stone or gravel, or a combination of stone and gravel, with bitumen.

Bituminous composition pavements should be placed upon well prepared foundations of concrete made of broken stone, with hydraulic lime or bitumen as the matrix.

Such a foundation has been made use of in all cases in France and England, and it is to that fact, in conjunction with the more thorough manner in which the work is done abroad, that is to be attributed, to a large degree, the success that has attended such work. Pavements have been laid in this country on road-beds utterly unfit to receive them, without special treatment.

The nature and condition of the foundation has been deemed to be of little importance, apparently, by some manufacturers, either as deteriorating from or contributing to the integrity and durability of the superstructure, but many attempts to render a pavement, laid on a bad foundation, a lasting one have failed.

Preparatory to laying any part of the road-superstructure, the ground should be shaped and compacted to a carefully prepared surface, which should be parallel with the surface of the superstructure when finished. Soft or uncertain ground and special localities where the deposits of objectionable material occur, should be remedied by replacing it with stone, gravel, sand, or other reliable substitute.

Moist, marshy, or springy ground occurring within the line of the streets, should be treated so as to prevent the possibility of settling, or the working up of water through the structure,

either by excavating and replacing the objectionable material, as above noted, or by leading the water, by tile or otherwise, beyond the line of the roadway.

This surfacing should have suitable crowning to carry off any water that might find its way through the upper courses, and so reduce the risk of damage by frost. Upon the natural surface thus arranged, unless it should be of a porous nature, it would still further add to the completeness of preparation, if a layer of sand, gravel, or other loose material were placed over the entire surface.

Upon the road-bed thus prepared, a layer or foundation of properly made concrete is to be laid, varying in thickness, as hereinafter indicated, according to the use to which the roadway is to be subjected.

In any case, whether hydraulic lime or bitumen is used as the concreting substance, the material must be allowed to set properly.

The Board are of the opinion that the strength and durability of the road largely depends upon the thoroughness with which this part of the work is done.

It is very desirable that the finishing surface should in no case be placed upon the foundation course until all the moisture is expelled, and until the concrete has become sufficiently indurated to prevent any movement of the material composing it, when walked upon.

Moisture, in connection with the preparation and application of the bituminous compound, must be entirely removed before it can be safe to use it, as the presence of water seriously interferes with the adhesive properties of the bitumen. No material should be manipulated during and exposed to wet weather, and material, for like reason, which had been rained upon, should not be laid until thoroughly dried.

A bituminous concrete pavement cannot, in the true sense, be made elastic, although we are accustomed to speak of it as a semi-elastic material; meaning that, by slightly tempering it, it is found to conform more readily to the changes of temperature, the range and alternations of which, in this country, no doubt place them among the most serious dangers to which these pavements are exposed.

The proper use of material necessary to secure a combination

which will adapt itself most effectively to the changes of temperature, avoiding liability to excessive softening in summer, and to the frequent and uncertain cracking by contraction, in winter, to which a rigid compound is exposed, is a very important result to attain.

Geographical position will vary somewhat the relative proportions of certain ingredients required to produce the condition alluded to, but experience and intelligent observation will determine very nearly the manner of securing the desired end. The surfacing material will, of course, vary in depth, according to the uses for which the road is intended, as well as to the different views entertained by the several patentees. In any event, it should be applied with uniformity as to the thickness of the various grades of material used; compacting, by rolling or otherwise, should be carefully and thoroughly done, to secure uniform solidity and density of surface, as insuring more complete impermeability to water. This material will be found to consolidate under the pressure of traffic, and it is believed that the surfaces will harden to some extent by exposure.

Various artificial means are resorted to, to harden these compounds—notably the use of sulphur, sulphuric acid, oxide of iron, cement and lime. Some of these materials *will* no doubt harden these compositions, but except with great care and a knowledge of their use, will add no permanent value to the pavement, while, on the contrary, any imprudent or excessive use would produce defective surfaces, liable to excessive abrasion as well as rapid disintegration.

The use of any such substances, which in themselves are not of a durable nature, or which in conjunction with other matter do not change character or produce chemical combination with other ingredients, is to be condemned, and an offer to do work under patents comprehending the use of such material, should subject the proposition for doing work under such circumstances to the severest tests of examination, as well as the work itself, if allowed to be done, before its acceptance.

All the processes of manufacturing these pavements, and especially the application of the concrete foundation and surfacing materials, should be carried on in a careful and deliberate manner. No hurried or imperfect work should be permitted under any circumstances. All the work should be done under

the very best combination of circumstances, and compromise will be at the expense of the work, and in case of failure will largely relieve the contractor of his responsibiliiy. Thorough and perfect work at the outset will be found to give the greater satisfaction, and will prove most economical, for the reason that, however the contractor may be bound to insure perfect work, the repaired surface will not always be as good as the original, and the occupation of a street for the second time will prove both annoying and uneconomical.

The laying of these pavements should be limited and restricted to fine weather, a moderate temperature and reasonably dry atmosphere being unquestionably the most favorable combinations. These conditions are, possibly, best secured within the period from April 1st to December 1st, but may be exceeded in either case, according to the locality of operations and the kind of weather prevailing at the time. This recommendation is simply intended to ndicate, in a general way, that the prevalence of damp and frosty weather is unfavorable for this class of work.

The necessity of prompt repair of all worn or defective surfaces is apparent, so long as the concrete foundation is preserved intact, the work of repair is confined to supplying the surface coating only, and its partial or entire restoration will be comparatively inexpensive. The system adopted in Paris and elsewhere, by which repairs are made as soon as the smallest defect is observed, and before the defective portion is permitted to be enlarged or still further complicated by wear, is in all respects a desirable one to adopt in this country, and any organization or corporation having pavements of this character to any extent under their charge, will find it economical to keep in constant employ a small corps of skilled laborers who, by practice and experience, will become proficient in repairing it, and it is believed that the cost of maintenance will then be reduced to the minimum.

The merits of a well-made composition pavement are many; assuming that its construction, as to material used and manner of manipulating them, is carried on upon the basis of the recommendations and suggestions contained in this report.

It should be a durable pavement; enconomy in first cost should constitute one of its first advantages; repairs should be comparatively inexpensive.

The freedom from dust in dry weather and from mud in bad weather, over other pavements, together with the facility with which it can be kept clean, is also clearly demonstrable, and in large cities and much traveled streets this will undoubtedly prove very desirable.

The smoothness and regularity of the surfaces specially commend it as a traffic road, in view of the fact that it requires the minimum tractive power to a given load, exacting, so far as this class of roads is concerned, less strength and weight of vehicle —a consequent reduction of the dead weight and a corresponding increase in the paying load.

This pavement is free to a noticeable degree from noise and jar, and otherwise offers conditions favorable to the comfort and effectiveness of horses, and adds somewhat to the happiness of sensitive humanity.

All pavements of this character must prove valuable in a sanitary point of view, in that they do not absorb water to any appreciable degree ; they prevent exhalations of noxious gases, the material (bitumen) being a known antiseptic. Their cleanliness is also a great recommendation.

Finally, the conclusions arrived at, as the result of the examination and discussions of the Board, may be briefly stated as follows :

First.—The enforcement of a system of heating asphalt and coal-tar bitumen, developed under competent chemical investigation, by which a comparatively uniform standard of quality and character may be established. In this connection it is suggested that a series of trials with material so prepared, under the direction of this Board, be authorized.

Second.—The adoption of improved machinery and of heating by steam, for all purposes of manipulating the materials to be used.

Third.—All the work to be done in the manner hereinbefore described, and in accordance with given formula or specifica-

tions, under the supervision of an engineer or other competent person.

Fourth.—It is recommended that, in all cases where it may be possible, sewers, gas, and water pipe and needed connections shall be put within the lines of the street and sidewalks, a sufficient time in advance to allow for proper settlement and repairs.

It is believed that better work will result if the road-bed and foundation course of concrete is prepared and laid for the contractor, and the Board therefore recommend that, wherever it may be practicable, that this portion of the work shall be prepared in the most careful and thorough manner, ready for and preparatory to the work of surfacing with bituminous material.

The accompanying sketch shows the sections of three classes of roadway and walk, and while the dimensions may vary under certain circumstances, the Board is of opinion that their adoption as a minimum will secure in all cases a more complete and durable roadway than has heretofore been offered to the public.

Much time would be necessarily consumed in properly testing the various processes herein outlined, and following out results by careful experiments, but the Board are convinced that the present system of manufacturing bituminous pavements is in need of entire reform, and they beg to suggest in this report the direction and manner of improvement which their investigations seem to point out. It is certain that radical changes in the treatment of material and their manipulation is necessary, and would greatly facilitate the proper development of a class of work in which the public is so largely interested, and which, if found to succeed better by the adoption of these suggestions, or if the resulting investigations will develop more correct principles for the preparation and use of materials in this class of pavements, much good will have thereby been accomplished, and an important and

increasing branch of industry and enterprise will be added to the successful labor of the country.

M. A. KELLOGG,
Eng. in Chief D. P. Parks, New York,
President.

JNO. Y. CULYER,
Chief Eng. Brooklyn Parks Commission,
Secretary.

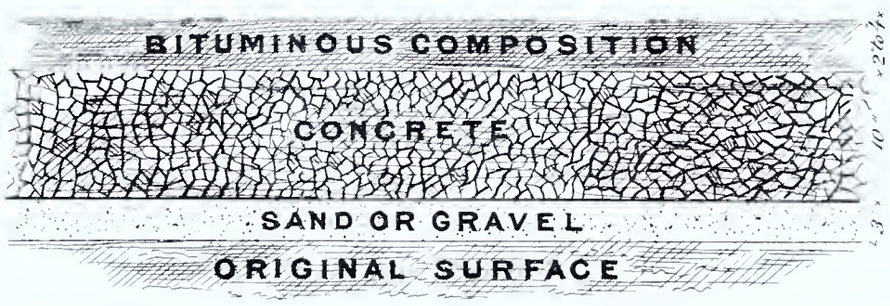
JUS. D. ESTABROOK,
Prin. Asst. Eng., Fairmount Park,
Philadelphia.

A. B. MULLETT,
Chief Eng. Metropolitan Bd. of Pub. Works,
Washington.

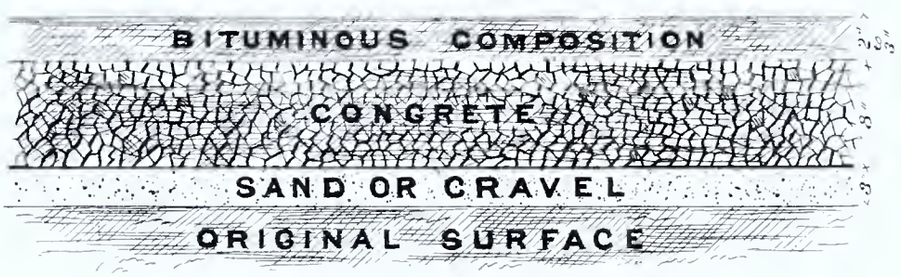
S. P. BROWN,
Metropolitan Bd. of Pub. Works,
Washington.

O. E. BABCOCK,
Major Engineers, U. S. A., in charge of Public Buildings and Grounds.

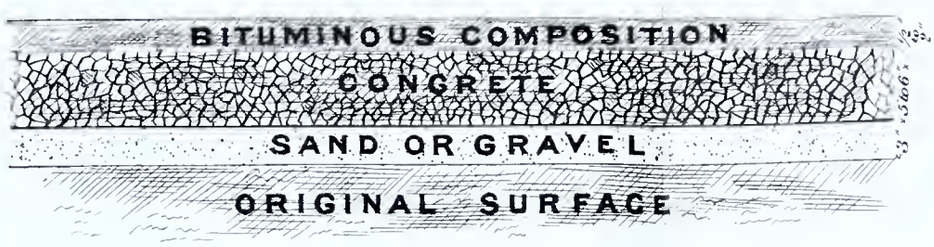
Road for Heavy Traffic.
Portion of section (enlarged)



Road for light Traffic.
Portion of section (enlarged)



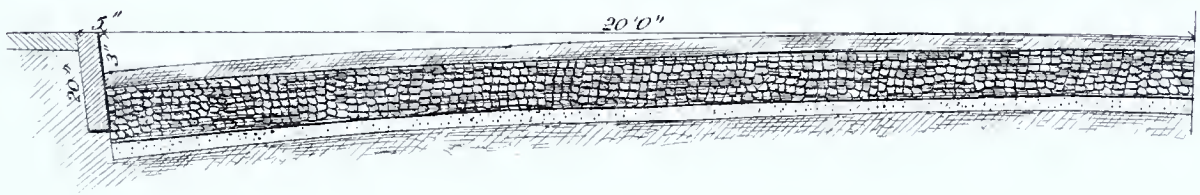
Park Road.
Portion of Section (enlarged)



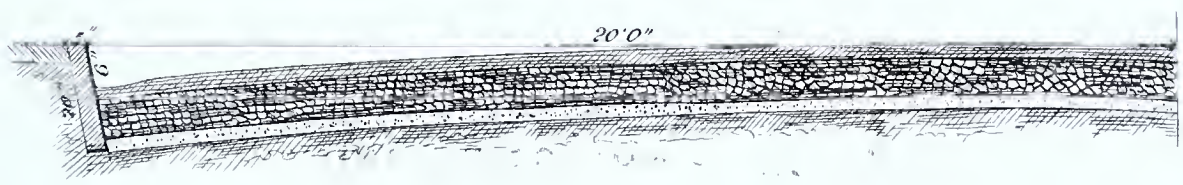
Walk.
Portion of Section (enlarged)

SCALE 0 1 2 OF FEET.

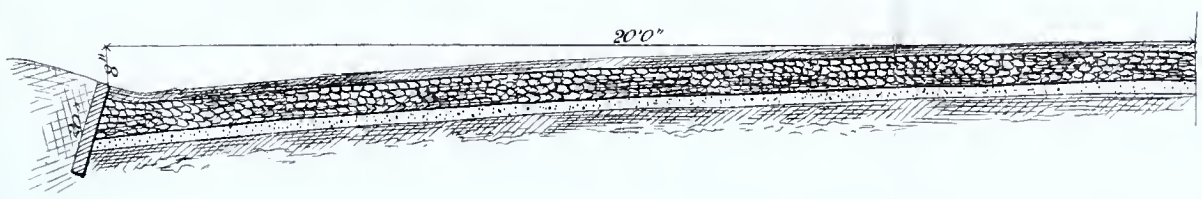
Half Section of Road or Heavy Traffic.



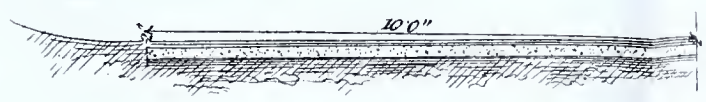
Half Section of Road for Light Traffic.



Half Section of Park Road



Half Section of Walk



SCALE 0 1 2 3 4 5 6 7 8 9 10 OF FEET.